TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. XXII NO. 1 JANUARY, 1945 PRICE 6d

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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

Cables :: "Stomata." | Phone :: 0365

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FUNDAMENTAL SCIENTIFIC RESEARCH

We reproduce below extracts* from an address by Sir Edward Appleton, F.R.S., given not long ago to the Chamber of Commerce, Manchester, in which he discussed the subject of fundamental scientific research.

"I do not propose," he said "to expound here my owns views on the conflict of opinions concerning the calling of science. But I would like strenuously to oppose the view that there are superior and inferior forms of scientific activity according to whether there is or is not a practical or human end in view. I want to break down the distinction between what is called pure and applied research, believing that they are essentially one, in that, whatever may be the stated objective, they are pursued by the same method and with the same permutations and combinations of observation, theory, and experiment."

"Nor do I think it very profitable to attempt to decide, as people have tried to do, which is the more important, a great discovery in pure science or a great discovery in applied science. But within the present century, owing to the impact of many scientific discoveries in our practical life, the general public has become so accustomed to the enjoyment of the fruits of science that there is a great danger lest it should regard the scientist as a servant whose task is solely to produce a succession of discoveries of immediate use to industry or directly to the individual member of the community. I believe that this exclusive concentration on the practical products of science in the public mind has to a large extent been fostered by events during the war when almost the whole of our scientific effort has necessarily been directed to investigations of short-term practical utility."

"The main theme of my talk, then, is to be the wisdom of ensuring that there shall continue to be in this country many active research groups whose scientific work shall be that of free inquiry and the extension of man's knowledge of nature, unconcerned whether the final results are to be of practical use to humanity or not. I hope to show you that this is, indeed, one of the surest ways to a harvest of practical usefulness."

"The matter was well put many years ago by Professor A. W. Hofmann, under whom the famous

* *Jr. of Counc. for Scientific and Industrial Research*, 17, *No.* 3, 1944.

Perkins was working when he discovered the first aniline dye. Hofmann, in one of his addresses once wrote :—

"Whenever one of your chemical friends, full of enthusiasm, exhibits and explains to you his newly-discovered compound, you will not cool his noble ardour by asking him that most terrible of all questions, what is its use? Will your compound bleach or dye? Will it shave? May it be used as a substitute for leather? Let him go quietly on with his work. The dye, the leather will make their appearance in due time. Let him, I repeat, perform his task. Let him indulge in the pursuit of truth—pure and simple—for the sake of truth."

"But I would like to add a postscript to those words of Hofmann's, for it illustrates my second point, and that is, that although our young chemical discoverer should be encouraged to go on with his work with the object as stated by Hofmann, I think it is equally important that there should be some other, more practical, man eager to test whether the new compound will bleach or dye. In other words, I regard it as essential that our applied scientists should keep themselves constantly in touch with the development of new knowledge, in order that the gap between discovery and its application should be bridged as quickly as possible."

"I want to say a few words about the way fundamental research is carried out and about the conditions which seem to conduce to its successful prosecution. But the first thing to be said is that it is quite impossible to generalize about such matters, for important discoveries have been made in so many different ways. Chance often plays an important part, but the success really follows from a combination of chance and the prepared mind. Generally, I would say that fundamental scientific work flourishes most abundantly in an atmosphere of freedom, though I have known many a success follow from a young man's being persuaded, if not actually ordered, by his professor to leave a tempting side road and return to the main road on which he had embarked in the first instance. Sometimes people work best in teams, and such types of organization are often essential for attacking certain types of problems. Sometimes, on the other hand, people work best singly. We must recognize these differences and allow for them."

"I now turn to the subject of the organization of fundamental research and the provision for it. I think it cannot be disputed that we must look to our universities for the main body of our fundamental research. There the easy contact and intercourse between workers in different fields can readily take place. A university atmosphere also gives that sense of freedom which so many of out best workers find essential to their best work. But experimental work nowadays usually costs money. Gone are the days when "sealing wax and string" according to the old Cambridge formula, will suffice. It is for this reason that grants for apparatus and assistance are given by Government Departments to university workers whose work is deemed to merit support. We must, I think, recognize in this connexion the importance of the exceptional man in the field of scientific research, the man with originality and imagination. It is far more important that he should be supplied with the facilities he needs and allowed, if he happens to work in that way, to inspire his team of juniors, that a number of other people should be encouraged to continue more pedestrian investigations."

"But I also believe that industrial research organizations and the research departments of Government should contribute their share to the general body of fundamental knowledge. Many big and enlightened industrial concerns regard it as a good investment."

"I also believe it to be the function of the three chief civilian research organizations of Government —the Agricultural Research Council, the Department of Scientific and Industrial Research, and the Medical Research Council - to pursue fundamental research in fields which are ultimately likely to be of practical benefit to the general community. In considering research, we should, in particular, note the change in the function of Government in becoming less negative and more positive. In Graham Wallas' famous phrase, it "has come to be engaged not merely in preventing wrong things from being done, but in bringing it about that right things shall be done." In other words, its operation has ceased to be concerned solely with the safeguarding of rights and liberties and the prevention of crimes and abuses. It is now charged, in addition, with the active improvement of the welfare of the citizens of the country, and certain aspects of such improvement need scientific knowledge, some of which is available and only need interpretation, and some of which has yet to be acquired."

"I confidently believe that there is now a general awakening on the part of both Government and British industry to the importance of scientific research and the need for its extension and application."

"There will, I feel sure, be large post-war developments in industrial research and technology, but I want them to be sustained by an adequate volume of fundamental research. If the tree is to continue to bear fruit, we must ensure that there is healthy growth in its roots."

EMPIRE COTTON GROWING CORPORATION

At a recent meeting of the Executive Committee of the Corporation a letter was read from Lord Derby in which he explained that he felt obliged to ask the Corporation to accept his resignation of the Presidency of its Administrative Council. He intended to continue to take the same interest as heretofore in the work that the Corporation was carrying out, but he regretted that he was no longer able to participate actively in it. The Committee decided that they had no option in the circumstances but to accept his Lordship's resignation with very deep regret, and they recorded their great indebtedness to him for the invaluable assistance he had given to the Corporation as President of the Council since its incorporation in 1921. It was further decided to invite Lord Derby to become Patron of the Corporation, a suggestion to which he has glady acceded.

CO-OPERATIVE CREDIT SOCIETIES IN THE SOUTH CARIBBEAN AREA—*Concluded*

BY

A. R. STANIFORTH

(Adapted from a dissertation presented in part fulfilment of the requirements for the Associateship of the Imperial College of Tropical Agriculture)

A Critical Examination of the Principles and Methods Involved in the Three Groups of Co-operative Credit Societies

Control and Management

In the West Indies, the peasants themselves have never spontaneously organised their own credit society movements. The initiative has always come from Governments interested in peasant agriculture, and the ideal, envisaged by European apostles of Co-operation, of societies of hard-headed and benevolent countrymen organising their own banking system cannot be put into practice among the small farmers of Trinidad or British Guiana. Of all the societies studied, only the predominantly urban Georgetown Co-operative Credit Bank in British Guiana appeared capable of managing its own affairs efficiently.

In St. Vincent, a co-operative credit movement which should have done good work among the small farmers there, was left to run itself. Recommendations made by Professor Shephard in 1931 that a competent officer be put in charge were disregarded, and there can be little doubt that the collapse of the St. Vincent co-operative credit movement was due, primarily, to the lack of proper supervision. In Trinidad and Tobago the Government controlled credit societies were in very bad shape until 1932, when a competent inspector was appointed; but, since then, the efficiency of the movement has increased as the supervising staff has been improved. In British Guiana, since 1917, the movement has been supervised by at least one whole-time Government officer and the banks there have never become disorganised. One cannot fail to connect the level efficiency of the Usine Ste. Madeleine societies, after they had been extricated from financial difficulties after 1921, with the adequate staff maintained by the Company for their control. All the evidence goes emphatically to prove that sufficient capable and impartial outside guidance must be provided for a credit society movement, if efficiency is to be maintained. In addition, it is obvious that it will pay any body to supervise societies in which that body has a considerable financial stake.

It should be the aim of any Government starting a credit society movement to set up a sufficient number of societies to warrant the appointment of a qualified officer as Registrar, to be responsible for the direction of the movement. The system in the Trinidad Government societies, where decisions must be made in San Fernando and again in Port-of-Spain, and where copies of many forms must be filed in two Government offices as well as in society offices, still falls short of the ideal. The excellent Usine Ste. Madeleine system of control could not work in many areas. But it is suggested that a credit movement on similar lines might well be worked in conjunction with a marketing organisation such as the central cotton ginnery in St. Vincent.

Cost of Administration

It is suggested that Governments which sponsor Co-operative credit should decide whether they intend to subsidise societies in the belief that the resultant greater peasant prosperity will bring recompense, or whether they intend the movement to pay directly for its own administrative expense. If Government takes the first attitude, it can be said that a parsimonious policy of supervision will not lead to success, while the interest charged by Government on loans to societies can hardly be too low. If Government assumes the second attitude, figures presented in this article show that, in some circumstances, co-operative credit could hope to be successful as a business concern. Total Government expenses in organising the British Guiana credit banks have amounted since the start of the movement, to less than 5 per cent. per annum on the total of loans held per annum by members of these banks. In Trinidad, the total expense incurred by the Government in organising the societies which it finances has amounted during the whole life of the movement to about 12 per cent. of the total loans made to members, but the low 3 per cent. rate of interest at present charged on the sum of $150,000 (already voted in 1944 for advancing to societies) would recover the whole of the present administrative cost. There is, of course, no prospect of Government recovering its administrative expenses in this way unless it supplies a substantial part of the banks' working capital.

The Limitation of Liability

Societies of unlimited liability have been thought to imply a system under which completely unpropertied members of good character could obtain loans because their fellows stood joint surety for them. But, although loans have become irrecoverable in the Trinidad societies professing unlimited liability, there has never, except in the specialised Usine Ste. Madeleine group, been an example of a society levy on all the jointly liable members. This is due, not so much to slack management, as to the acknowledged

fact that it is inexpedient as well as difficult to levy on a group of members—unless the management has such a control over all members' incomes as the Usine Ste. Madeleine has. Except in this latter instance, any enforcement of unlimited liability has been in the degenerate form of occasionally dipping into societies accumulated profits to recover members' bad debts.

In all three groups, societies in practice require members to pledge sufficient security of their own or to find fellow members who are prepared to stand surety for them. In Trinidad, security offered by the borrowers of 31 societies in 1942 was valued at ten times the value of loans given. It has been found, in the actual working of Government organised credit societies in Trinidad and Tobago and in British Guiana, that the working capital with which these societies have been provided is in no safer state when it is theoretically backed by the joint security of members; in instances of default, members' losses are limited, in all but the Usine Ste. Madeleine societies, to members' paid-up cash contributions to societies' funds. In setting up new groups of credit societies in the West Indies there would seem to be no point in arranging for any form of unlimited liability.

Saving

The importance of saving in credit societies cannot be too strongly emphasised. In the West Indies as elsewhere societies are often regarded merely as vehicles for the disbursement of government money—government being the universal provider which never runs short. Credit society movements in the tropics nearly all have the same history—wild lending in good times when money should have been saved, and a drastic restriction in the flow of money in bad times (just when more money is most urgently needed) when government *did* refuse further aid.

Shares and Subscriptions

The British Guiana banks had subscribed share capital amounting to $70,000 by 1921, and they were able to continue to make loans of between $20,000 and $40,000 per annum during the depression years, when no new loans were granted by Government. Though this continuance of business was partly due to the fact that Government loans were repayable over 25 years, it is also undoubtedly partly due to the banks' possession of share capital. The Trinidad societies which were entirely dependent on Government for working capital were extremely inactive during these years.

Shares in British Guiana have the advantages that they are non-repayable during the banks' working life, while the interest on shares can be adjusted to suit banks' financial circumstances, and is often not claimed. These advantages make for greater flexibility in the system.

By far the largest proportion of shares in British Guiana were taken out in small amounts—averaging $8 to each member—and there are no more than ten instances of monied people taking out the maximum $240 worth of shares primarily because the bank offered a 6 per cent. rate of interest. Thousands of dividends have never been claimed. The real reason for the taking out of shares was the insistence in early years that loans would be made to members only in strict ratio to the members' share holding, and it is important to note that the bulk of share capital in British Guiana was subscribed in the years when money was plentiful between 1915 and 1921. The very low percentage of shareholders who are still sufficiently interested in the credit banks to take loans, together with the fact that thousands of dividends remain uncollected, seems to indicate that many of the original shareholders have ceased to take any active interest in their shareholding. Nevertheless, the usually tiny dividends, though very often not collected, are still calculated annually and entered in the societies' books; and provision must be made for individual dealing in each share.

It seems that, so far as members are concerned, little practical difference would be entailed by making all the small shares in British Guiana non-transferable and non-interest bearing—in fact converting them into simple subscriptions, while the simplification in society book-keeping would be comparatively immense.

It may be concluded that share capital has many advantages but that there are disadvantages in the financial manipulation of very small shares. Simple subscriptions should be better than such small shares. Peasants show no signs of voluntarily taking out either shares or simple subscriptions, but the subscription of such working capital may be stimulated in good times by the provision of a mechanism such as the loan-share ratio.

Deposits

In Trinidad an attempt was made to start compulsory saving by deducting a percentage of all loans made and carrying the deductions to members' savings accounts. It was difficult to know, however, what interest could be paid on such deposits and when the deposits could be withdrawn. The scheme was abandoned soon after its inception and it would appear that this form of saving would be less satisfactory than shares or simple subscriptions.

Interest Rate on Loan to Members

In the past, interest rates on loans to members have been arbitrarily fixed, and not related to business requirements. It is, in fact, impossible to tell what rate a peasant can afford to pay, for the use of a loan to be economical, but figures can be provided upon which it is possible to base a sound determination of interest rates from the societies' point of view. In all British Guiana

banks the average loan made during the five years 1938-1942 was $39 and this loan was held, on the average, for about 2½ years. Interest at 3½ per cent. per annum on such a loan would amount to about $3.50. The average expense per borrower in all these societies is just about $3.50. Clearly, interest at 3½ per cent. over and above the rate which these banks have to pay for the use of working capital is just sufficient to cover all expenses entailed in making such loans. The calculation will vary for individual societies, but figures upon which the calculation may be based are given for all societies over five years old in each group in the original thesis.*

Societies have accumulated and can continue to accumulate their own working capital if they charge members a sufficient rate of interest to leave an annual profit after administrative expenses are met. This method of saving is slow but effective and it is recommended that, if neither shares, deposits nor subscriptions can be introduced into a credit system, then interest rates to members should be made high enough to allow the accumulation of profits.

Purposes for which Loans should be Granted

After many enquiries, the writer came to the conclusion that moneylenders were not a social evil in the Southern Caribbean. Nor has shop-keeper credit been of great importance since the beginning of the war. Even if it were considered advisable for credit societies to take over money lender or shop-keeper debts, one must conclude that in most West Indian colonies the question does not arise.

Investment must be useless if the possibility for profit is absent, and it is now generally accepted that credit societies should make loans only for productive purposes. As a further general rule, it would seem best for peasants' investments to be made out of their own savings, but funds for the cultivation of crops which may occupy land for many months before yielding a return and for the sustenance of the cultivator during that time may be necessary. However, the evidence of various investigators seems to indicate that in many areas in the West Indies at least a third of all peasants receive one-third of their income in the form of wages earned off the farm often at those periods when their own crops are not yielding a return. It seems that such peasants should not need carry-over crop loans, and it is significant that the Usine Ste. Madeleine has never considered it necessary to extend loan facilities to the large group of part-time, wage-earning cane-farmers on their estates. Even among those peasants wholly or chiefly dependent for income upon their own land, there must be many who receive money from crop sales during most months of the year, and these also should be in little need of carry-over crop loans. It is suggested that the extension of crop loans to many of these farmers is only justified if, by so doing, the farmer can be persuaded to save, in the society. Otherwise, only whole-time farmers with long-term crops such as sugar cane should need crop loans.

No legal provision has been made for medium or long term loans in either Trinidad and Tobago or in British Guiana, but, if proposals for the re-organisation of peasant agriculture in the West Indies are to be implemented, then the need for longer term loans is likely to become important. Many loans for purposes normally considered to require a medium term for repayment have been made in British Guiana and repayments generally do not appear to have been unsatisfactory. One might say that British Guiana experience indicates that medium term loans can be made through credit societies.

The need for long term loans should not materialise unless the present favoured policy of leasehold tenure is abandoned or unless the construction of peasants' housing is to become more expensive than is now contemplated.

On general principles it would seem good to quicken the flow of money throughout the village community, and, in British Guiana, lending to shop-keepers and village artisans has been by no means unsatisfactory. There seems to be no reason why a suitably constituted village society should not be capable of making non-agricultural loans, and the resultant increase in business and membership should make for greater efficiency in society working.

The Length of Term of Loans

Whatever the purpose for which a loan is granted, the length of term allowed for repayment can only be soundly calculated by considering the length of time which that purpose will take to recover the investment; or, where the purpose for which the loan is granted is not itself remunerative, by considering the whole business of the borrower to discover how long it should take him to make sufficient profit to repay. But many of the troubles of co-operative credit have arisen because this logical procedure has not been adopted. The expedient of providing for wholesale renewals must be unbusiness-like, and it is recommended that no loan should be granted until a satisfactory term has been set and fully agreed upon between society and borrower. Recovery by instalment of all loans of longer term than one year should be a valuable principle.

Size of Credit Societies

There has been a strong opinion, based on experience of European Raffeisen banks, that membership of unlimited liability societies should be limited to small numbers who could know each other sufficiently intimately to stand joint surety for each and all. But unlimited liability is of no apparent practical significance in Trinidad, where loans are safeguarded in exactly the same manner as in British Guiana. If joint security

*Filed in the Library of the Imperial College of Tropical Agriculture.

is not practicable there is no clear argument for limiting membership to some small number such as 50, as in Trinidad, and, in practice in British Guiana, it has been found possible to run a successful bank with a membership of over 1,000. It is found in British Guiana that the important factor limiting the size of banks is really the area of country covered, since the area over which members are scattered seriously affects the accessibility to all members of the place of business, and also the ability of a cadre of committee members to make contact with all members' holdings.

On the other hand, there are sound arguments for having as large a membership as possible. As already stated, the big British Guiana credit banks have cost much less to administer in relation to business done than have the much smaller Trinidad societies. Several factors account for the more economical working. Secretaries of far greater efficiency can be appointed by the biggest societies (the efficient Essequibo bank with over 1,000 members can afford to pay $600 per annum for the services of a good secretary who is available in the society's office at stated times during most days of the week). Proper offices can be afforded by large societies. Chairmen and committee men of the right type are more easily found in big than in small societies. It is obvious that, in many ways, less time and trouble are required in the supervision of a few large societies than in supervising many small ones.

It would seem that the largest possible membership of suitable character, not confined to farmers, aggregated within a manageable area, usually the village or parish, should give the most efficient society operation. And although society memberships could not always be as high as in British Guiana, where the villages are unusually large, it is certainly a mistake to have more than one society in the same village.

Attendances at General Meetings

As far as business efficiency is concerned there does not seem to be any advantage in calling upon members to attend frequent society meetings. Except in the specialised Usine Ste. Madeleine group, good attendances at general meetings are unusual unless that meeting is directly concerned with the application for or granting of loans. It is suggested that if, for any purpose, a good attendance is required at a meeting, then that meeting must be made the occasion for loan application or granting. In societies such as those in British Guiana, which make loans in every month of the year, a high proportion of members will rarely attend one meeting.

Government Method of Making Loans to Societies

When the societies financed by Government in Trinidad and Tobago fell behind in loan repayments, Government decided to make no new loans to any society in any year until all previous loans had been repaid. This undoubtedly stimulates repayment, but it cramps the movement and leads to delays and hardship in seasons of difficulty. After bad floods had destroyed their crops, the members of a society in the lagoon area were actually congratulated by Government for having borrowed from outside sources in order to repay Government loans. Credit societies which are completely dependent on Government for working capital cannot hope to operate with complete efficiency so long as the principle of complete annual repayment is strictly enforced. In Trinidad the difficulties arising from the enforcement are aggravated by the extremely cumbersome governmental machinery for granting loans.

The defects of the Trinidad system are overcome by the method which has been used throughout in British Guiana, where loans have been made on the basis of repayment in 25 equal annual instalments of principal and interest. On $100 so loaned at 6 per cent., $4 principal and $3.12 interest would have to be repaid annually for 25 years. Under this system interest is light during the first half of the period of repayment but proportionately heavier in the second half, and it is claimed that this arrangement will help young societies. Moreover, when loans from Government are repaid in a number of annual instalments, societies retain the use of a balance of the loan for a number of years and can make loans for a term of more than one year and at any time in the year—provisions which are essential in any really successful credit system.

In practice, in British Guiana, the repayment of instalments of Government loans as they fell due was satisfactory, and although it may be claimed that the story might have been different if Government had supplied the whole of the banks' working capital, yet the experience of these banks is certainly in favour of the principle of recovery by instalment. So long as the lending operations of societies are efficiently supervised, it would seem that loans repayable in a number of equal annual instalments of principal and interest offer an excellent means of financing co-operative credit societies from Government funds.

Procedure in Making Loans to Society Members

Two essential provisions are needed before a society can safely make a loan. Sufficient security must be given and an analysis of the borrower's income must indicate an ability to repay. On the single form used by the British Guiana banks space is allowed for a proper statement of security offered, but no appraisement of the borrower's income can be made on the form. The evil of too great a reliance on collateral and of a disregard of ability to repay is shown by the fact that, in British Guiana, several banks have been forced to recover losses by themselves buying in defaulting members' property—a very unsatisfactory procedure. In Trinidad, the property valuation form now used

gives an excellent resumé of an applicant's belongings and of his crops and stock which are likely to bring in profit. The actual charging of security is arranged differently in the two colonies. In Trinidad an elaborate 'charge on crops'—a form of chattel mortgage—is made out in duplicate and legally registered. In British Guiana, a simple promissiory note is made out on the back of the application. In British Guiana, it is found that borrowers will repay, if they can, after having signed the promissory note, just as they will, in Trinidad, after having signed the charge on crops. If the borrower cannot pay, legal action can only be useful in a few instances as a warning to possible defaulters. If legal action has to be taken, the procedure in Trinidad is undoubtedly simpler, but it is highly questionable whether this simplification in a few instances compensates for the immense trouble of making out the charges in duplicate for every loan made.

It is suggested that the single form used in British Guiana gives substantially the same information as to the purposes for which the loan is required and the security which is offered as do the Trinidad forms, and that, for practical purposes, the promissory note supplies as strong a legal hold on the security offered as does the charge on crops used in the Trinidad societies. Only in the estimation of ability to repay is the Trinidad system of nine forms superior. It is recommended that one form such as is used in British Guiana, together with a form such as the property valuation form used in Trinidad and Tobago, would be a sufficient and the best means of making the small loans to members which constitute the total business of the societies there.

If there is any intention of making larger loans for the purchase of land, buildings or stock, then the chattel mortgage may be extremely useful and provision might be necessary for registering mortgages on land and immovable property.

Reserve Funds

The Trinidad legislation stipulates that reserve funds shall be built up until they equal one-fifth of the total working capital, while in British Guiana the Ordinance states that reserve funds shall be accumulated until they equal two-thirds of paid-up share capital. In both colonies the reserve fund is to be banked and used to cover any loss as shown by the societies' balance sheets. Two chief types of losses occur. First, the individual bad debts which must occur occasionally after faulty lending, even in the best managed societies; and, second, irrecoverable loans which follow unavoidable disasters such as floods or slumping markets, and which often occur in a mass. The latter type of loss is comparatively frequent in the West Indies, but reserve funds do not supply a satisfactory means of making them good, since there is no means by which the relief given can be related to contributions made. It should be possible to operate a form of insurance through societies to combat these disasters. Society reserve funds should be used to make good only the first kind of loss, and to do this they need to be no larger than a tenth of societies' working capital. The British Guiana and Usine Ste. Madeleine reserve funds (averaging respectively 1,228 and 249 dollars per society) are unnecessarily large, and it would appear to be very much more business-like to invest at least half of these accumulated funds in the business of the societies, where it can earn higher interest than in Government securities and at the same time reduce the amount of funds which have to be borrowed from outside sources.

Summary of Main Recommendations for West Indian Credit Societies

1. *Efficient governmental supervision is essential.*
2. A competent Registrar should be appointed with complete responsibility for the movement.
3. Cooperative credit should be regarded as a businesslike undertaking capable, if necessary, of paying its own way.
4. Unlimited liability is impracticable—members should only be made liable for their own, paid-up contributions to society capital.
5. *Societies must concentrate on saving working capital of their own in good times.*
   (*a*) Shares offer a practical means of saving.
   (*b*) Non-interest bearing and non-transferable subscriptions would operate in a manner similar to small shares and would be less troublesome.
   (*c*) Deposits do not seem satisfactory.
   (*d*) The interest on loans to members can be adjusted so that societies can accumulate profits.
6. Societies should have the largest possible membership of suitable character, not necessarily all farmers, within suitable aggregations of population.
7. Large attendances at numerous meetings are not necessary for financial efficiency, but good attendances, if desired for other reasons, may be stimulated by making general meetings the occasion for loan granting.
8. Government loans to societies can well be made repayable in instalments over a number of years. There should be no insistence on the complete repayment of all previous loans before the granting of fresh loans.
9. Few and simple forms should be used in making the small loans in which credit societies specialise. Two forms—one such as the single form now used in British Guiana together with one similar to the property valuation form used in Trinidad—are recommended.
10. An extension of short term crop loans may be justified in many circumstances only if they are a means of making borrowers save. Societies can make medium term loans.

11. Loans should be made available for suitable non-agricultural as well as for agricultural purposes.
12. The term of a loan must be based on the time needed for repayment and this term must be strictly agreed upon with the borrower.
13. Loans to members of longer term than one year should be repayable in instalments.
14. Reserve funds should not exceed one-tenth of working capital.

Conclusion

The word 'Co-operation' has appeared seldom in this article because practically no evidence of conscious co-operative spirit has been forthcoming among the mass of society members in Trinidad and Tobago and in British Guiana. The experience in these two colonies indicates emphatically that credit cannot be brought to the peasant population by means of a pious exposition of the principle of self help and mutual support. All the evidence is in favour of a more business-like attitude.

But dropping the emphasis on the word 'Co-operation' does not mean giving up hope of supplying peasants with credit at reasonable rates. When shorn of the hyprocisy of mutual beneficence, the credit society still provides a number of indispensable aids. The grouping and assembly of village populations makes the first step towards the possibility of cheapening credit. And one does find among these groups of peasants, as among most communities of the world, men who like public responsibility and who find congenial employment in unpaid committee work. As district committee members in credit societies, these men are, and can continue to be, a real factor in the cheapening of rural credit.

In the past, co-operative credit in tropical colonies has tended to be a mixture of business and altruism. Mark Twain said there was no true altruism; but, whether this be accepted or not, it is a fact that altruism and business efficiency are incompatible concepts. It is the plea of this article that the operation of credit societies (which have a purely business function to perform) can be successful only if conducted on really business-like lines; and it is hoped that some information has been provided which will aid the organisers of peasant credit in the West Indies in formulating a businesslike policy.

Acknowledgments

I am extremely grateful to Mr. O. T. Faulkner (Principal, Imperial College) for the encouragement he has given during the progress of the work, and for the many valuable criticisms and suggestions he has made. I also wish to thank Mr. R. O. Williams (Acting Director of Agriculture, Trinidad), Mr. L. D. Cleare (Acting Director of Agriculture, British Guiana), Mr. G. B. Westwood (General Manager, Usine Ste. Madeleine) and Mr. C. K. Robinson (Agricultural Superintendent, St. Vincent) for giving me access to society records. I am particularly grateful to Mr. C. K. Hutchinson (Inspector of Credit Societies, Trinidad), Mr. K. McKenzie (Cane-farmer's Superintendent, Usine Ste. Madeleine), and Mr. W. G. Delph (Registrar of Credit Banks, British Guiana) for giving me the freedom of their offices and for discussing with me many of the problems of co-operative credit.

MANAGEMENT OF CINCHONA PLANTATIONS

In an article in the *Bull. Agric. Congo Belge*, 34, 1943, the management of Cinchona plantations in Kivu, Belgian Congo, is discussed with special reference to the lessons to be learnt from the methods employed in Java. In Java the best yields are obtained by close planting, say 90×90 cm. with subsequent thinning conducted as follows. In the third year the branches of all the trees are cut back about 6 ft. or to within 3 ft. of the ground and the bark of these loppings is collected. Pruning continues in the fourth year and weakly trees are cut out entirely. In the fifth and sixth years thinning by tree removal begins. It is axiomatic that, when the branches of adjoining trees begin to interlace, pruning or tree removal should be carried out, and on a well managed plantation this should occur annually. The importance of light and air to the interior of the plantation has been proved. Selective thinning is advised, choosing particularly any spindly trees, or ledgers which approach the *Succirubra* type. Trees showing promise of good future development should be retained. They are easily recognized by their solid trunk and heavy branches and thick bark. This selection requires careful supervision by the management; it cannot profitably be left to native labour. The trees reach full development in 15 to 30 years in Java. When their branches no longer meet overhead or when the yield from prunings and thinnings falls below 70 kg. sulphate of quinine per acre the plantation is cut down. The African plantations are still too young for the age of maturity to be determined and it will probably depend on altitude. The bark is peeled by hand; the local method is described. The small twigs of pencil thickness form one-eighth of the prunings or 12.5 per cent. of the yield, but a man can only strip 3 kg. of this bark per 8 hour day as against 10.33 kg. and 16 kg. for branches of 1 in. and over 1 in. thickness respectively. In Java, if the price of quinine falls below a certain level, the small twigs are not used. The stripped bark in Africa is given a preliminary drying in the sun and broken into small pieces by child labour, a final drying is given by artificial means, preferably at a temperature of 75°C. At 105°C. there is liable to be some loss of alkaloids. Weight of dry bark is about one-third that of fresh bark. Packing can be done in ordinary sacks without paper lining. To secure the best prices the bark of the roots should not be mixed with that of trunks and branches.—(*Hort. Abst.*, Vol. XIV, No. 3, 1944.)

SCIENCE IN SUGAR PRODUCTION *

BY

F. HARDY

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This Conference is the first in which a Field and Soil Section has been joined to the Sugar Technology and Engineering Section of the British West Indies Sugar Association, and it thus offers a fitting occasion for some brief suggestions concerning possible profitable lines of future research and means of broadening the scope of sugar investigations. The need has evidently now arisen for closer co-ordination of field and factory activities. The experimental work in the past has perhaps suffered somewhat from over-specialisation in a limited number of aspects; it has owed "too much to too few". It is interesting to note at the outset that a similar need for closer field and factory co-operation has apparently also arisen in South Africa, where in a recent conference (1), the desirability of a more fundamental approach to the problems of cane-sugar production was emphasised.

Factors involved in the production of cane-sugar

The following fundamental equation (2) introduces a kind of sugar accountancy that may perhaps appear a little strange to office workers. It stresses the fact that the final yield of cane-sugar "in the bag" is controlled by several important agencies ("independent variables"), operating both in the field and in the factory, whose relative importance and efficacy yet remain to be ascertained and evaluated.

Equation I

Sugar Yield=f (Cane Plant; Soil; Climate; Topography; Time; Factory; Man.)

This equation implies among other things that "soil fertility" is not the only factor deciding sugar yield; many different soil properties are involved besides nutrient status, in addition to external climatic factors which unfortunately we cannot control except where irrigation can be practised. It is true that each cane-growing area has its own specific fertilizer problems, but we evidently need a much broader outlook in our investigations into the interactions between climate,† plant and soil if our object is to increase sugar production economically.

In order to gauge the efficacy by any one factor in the fundamental equation, it is necessary to keep all the other factors constant. This can seldom be done in practice, but the principle at least provides comfort for sugar technologists and engineers since the efficiency of the sugar factory is not the only factor responsible for final yield of sugar, nor indeed for the behaviour of the cane during processing. It is true that "the manufacture of sugar begins in the field", yet managers who demand a high recovery of sugar in the factory are often content with but a small yield of cane in the field.

It may be objected that the factor "soil" in Equation I is *not* an independent variable, in-as-much as its own properties are conditioned by some of the very same factors which decide yield, for it has been established that soil is itself the product of environmental factors; thus (2):—

Equation II

Soil Property=f (Soil Parent Material; Climate; Topography; Time; Organisms (vegetation, soil micro-organisms and man. . .)

This fallacy would disappear, of course, were we to substitute "Soil Parent Material" for "Soil" in Equation I. Further, the stressing of the activities of Man, and the replacement of Organisms—Vegetation by Cane-Plant in Equation I, so profoundly alter the effective biotic factor that the natural product "Soil" now automatically assumes the rank of parent material, and acts as the *initial stage* of a new process of soil development which may ultimately end in the formation of an entirely different kind of soil from that which originally occupied an area. Thus the agriculturists' conception of "Soil" differs implicitly from the scientific and more rigorous definition of the term. Examples clearly illustrating the changes that take place when a pre-existing soil-type becomes the "parent material" of a new man-made soil which is being utilised for growing sugar-cane intensively are to be found in Trinidad and British Guiana.

We need to be sure that the soil changes induced by man's activities and by the continuous cultivation of sugar-cane proceed in the right

*Opening address given by Professor Hardy at the 1943 Meeting of the British West Indies Sugar Technologists and reprinted from *The Proceedings of the Conference*, pp. 8-13.

†A striking illustration of the effect of *climate* on sugar production is furnished by the results of an experiment conducted by officers of the Hawaiian Sugar Planters Experiment Station in 1936 (3).

Two different soils, A and B, were put into tubs and planted with H109 variety of sugar-cane. One pair of tubs containing each soil, was set up at Makiki and another pair at Manoa where the climate is cooler, more humid and less sunny. After 14 months, the total amounts of sugar produced were compared as follows:—

	Soil A	*Soil B*	
At Makiki	...10.6 lb.	12.1 lb.	Favourable climate
At Manoa	... 3.4 lb.	2.5 lb.	Unfavourable climate

Both soils appeared to be "good" at Makiki but both appeared to be "bad" at Manoa.

direction, and that they will not result in irredeemable destruction of an initial legacy of soil fertility. To this end our soil investigations should not be too empirical; they should be so designed that they may reveal dynamic tendencies. The experimental testing of field operations too should be conducted with proper consideration of the essential inherent features of the soil and of the effect on these of the different agricultural treatments.

There are two distinct aspects of field investigations concerning the sugar industry, namely: (i) the comparative study of the effects of different environments on any chosen botanical variety of sugar-cane, and (ii) the comparative study of the effects of any particular environment on different cane varieties. It is advisable that these two aspects be studied simultaneously in each cane-growing region, and to this end, the prime need is that the various environments which each region presents should be fully described and clearly delineated. This is the first essential to any field research policy; it involves, but does not solely comprise, a particular kind of soil survey and the preparation of a series of special soil-maps showing such fundamental static features as land-slope, degree of erosion, subsoil drainage, soil texture and structure (deciding porosity), root-room, organic matter content, lime requirement, phosphate status, etc., as well as certain dynamic features, for example, moisture status, which fluctuate during the year. Such fundamental information is invaluable in attempting to interpret the results of manurial experiments and variety trials.

Sugar production should be considered both from its quantitative and its qualitative aspects. The first refers to yield of sugar per unit area of land, which mainly decides total output; the second refers to the behaviour of the cane and its juice in the factory, which largely decides sugar recovery. This aspect will be considered first as it concerns both field and factory personnel.

Quality of sugar-cane produced

By this term, as here used, are implied such features as "millability" of cane, "workability" and "claribility" of juice, "exhaustibility" of mother liquors, etc. Quality is decided by the chemical composition, properties and attributes of the cane-plant and its juice. It depends equally as much as yield of cane on the kind of plant (botanical variety), the kind of soil, perhaps topography, and certainly length of time of growth (or degree of maturity). The relative contribution which each of these factors makes to quality needs to be evaluated just as well as the contribution which each makes to quantity, but so far no attempt seems to have been made to study the quality aspect in detail.

(i) *Silica*: Recent research at this College has indicated that an important factor causing low claribility is the "organic-silica" content of the juice (4) which is relatively large for POJ 2878 as compared with BH 10(12) and Co 213, whose juice claribility is very much higher than that of POJ 2878 cane. It can be overcome by a fractional liming and double heating process. The fact that the trouble is stated not to be everywhere experienced (for example in Java and British Guiana) indicates that it is primarily caused by some soil factor not yet identified.

The content of "encrusting" silica, usually abundant in the peripheral tissues of grasses, may perhaps partly decide "millability" of cane, and this too deserves investigation. Also, silica is a frequent component of evaporator scale; here again its presence in cane-juice is undesirable.

In the soil, phosphate and silicate are mutually replaceable in certain chemical combinations (5), so that the silicate status of soil may be intimately linked with its phosphate status. Furthermore, both phosphate and silicate may be firmly fixed and thus rendered unavailable to plants by active hydrous iron oxides which occur naturally in certain soils. The cane agriculturist might thus be able, by means of suitable soil treatments, to reduce the difficulties of the factory operator with regard to silica interference.

(ii) *Carbohydrate non-sugars*: The deleterious effects on the factory features of cane-juice imparted by the presence of certain carbohydrate components such as pentosans, pectins, gums and mucilages, as well as by various products of the oxidation of glucose (6), many of which interfere with sugar manufacture, seem not to have been sufficiently considered, although preliminary determinations of uronic acid and methoxyl contents of cane juices have already been made (7). The mechanism of carbohydrate oxidation has been the subject of increasing study among biochemists in recent years; apparently in this process also phosphate is involved (8). The occurrence of water-soluble fructosan, plentiful in many grasses (9), has apparently not systematically been sought in the different varieties of sugar-cane. If present, it may furnish a reason for certain adverse colloidal phenomena which have so far not been explained. The relationship between colloidal carbohydrate content and physiological dryness of soil has not been examined, though it is known that the formation of these substances in plant saps is a frequent response to drought.

(iii) *Organic nitrogen compounds*: Proteins are stated to aid cane-juice clarification, presumably because they form stable flocs when the juice is heated and limed. Their possible loss through hydrolysis into peptones and amino-acids might thus be important and needs to be examined, as well as the relationship between protein content and the nitrogen status of soil.

(iv) *Inorganic salts ("ash" components)*: A large amount of work has already been performed on the effects of various nutrient soil components (10) and of added manures (11) on the composition of cane-juice, but final generalisation from the findings has proved difficult (12). Each cane-growing area and each system of cane agriculture appears to require examination strictly on its merits,

The phosphate problem (13), although it has been very intensively studied, still deserves further attention especially with regard to sucrose synthesis within the cane plant. While *phosphate* (and *nitrogen*) applied as manures, stimulate vegetative growth of the sugar-cane, they seem often to reduce sugar recovery in the factory. *Potash* appears to act differently in that it improves juice quality in some way. *Calcium* applied as limestone, sometimes proves beneficial, both to yields and juice quality, but sometimes its presence is deleterious, even though the uptake of calcium by the plant has been found to be uniform, regardless of the lime status of the soil. Most of the benefit seems to be attributable to the physical effects of liming on soil properties, but some has been traced to *manganese* which is often abundant in limestone. It has accordingly been suggested that juice quality in certain instances may partly be accounted for by the presence of manganese compounds in cane juice. This possibility, as well as the probable rôle of other trace elements in cane growth and juice quality, needs to be further examined. The case of *magnesium* is different, and its effect on juice quality, as well as its relationships to calcium, have apparently not yet been completely determined. Among the acid radicles, *sulphate* and *chloride* (which are superabundant in gypseous and saline cane soils) often exert deleterious effects on juice-quality; they also deserve additional study.

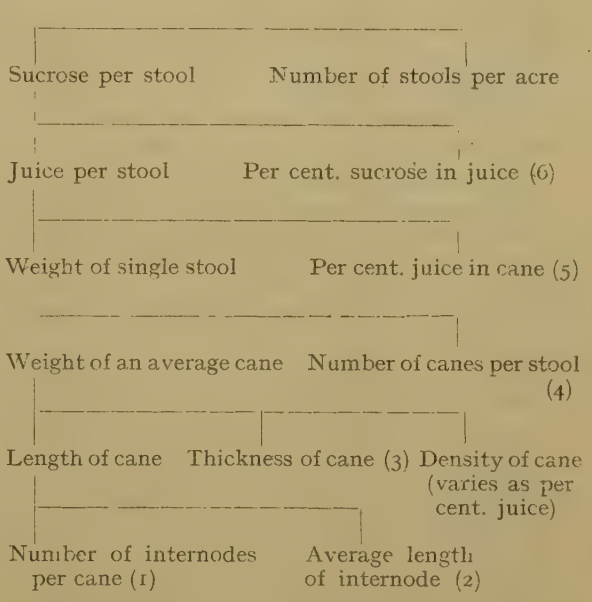
The further investigation of the various problems referred to above, while jointly concerning the factory chemist and his field counterpart, the soil chemist, also involve the sugar-cane breeder and geneticist, in-as-much as different varieties of sugar-cane take up, in different amount and degree, the various essential plant nutrients and other substances presented to them by the soil (14). Moreover, they exhibit different degrees of adaptation or "plastic response" to environmental conditions. The contribution which genetic strain makes to the general properties and behaviour of cane-juice in the factory needs to be fully acknowledged and assessed. The factory characteristics of all the chief varieties of commercial sugar-cane grown in fixed environments should, in theory, be severally studied.

Total quantity of sugar produced

Maximum yield of cane: According to agrobiological theory based on Mitscherlich's growth laws (15), the yielding capacities of crop-plants are inversely proportional to their characteristic nitrogen contents which, in a sense, thus measure their respective "life quantities". That particular genotype which can thrive best on the smallest quantity of nitrogen will therefore yield the largest crops when grown in a given soil. The maximum theoretical value for the nitrogen growth factor, according to Mitscherlich, is 318 lb. per acre. Hence, assuming that the nitrogen content of the whole cane plant is 0.084 per cent. by weight, (which is the nitrogen content of P.O.J. 2878 and H 109), the maximum yield of cane per acre should theoretically be nearly 170 tons, or about 25 tons of sucrose per acre. This high yield can only be attained when all the environmental growth factors are optimum. Nevertheless, records from Hawaii show that yields of plant canes of this order of magnitude have actually been attained, though the growth-period allowed has been long. In order to exceed this yield on suitable soils, it would be necessary therefore to evolve canes containing less than 0.084 per cent. nitrogen, which is a problem for the plant breeder of the future.

Apart from nitrogen metabolism, the ability of different cane varieties to take up and utilise the mineral nutrient elements (phosphate, potash, lime and magnesia) varies greatly, as has been amply proved in recent years (10). Some varieties therefore deplete the soil of nutrients faster than others, and their manurial requirements differ appreciably when they are grown in the same environment.

The inter-relationships of the various factors deciding the quantity of sucrose produced per acre of land are clearly shown in the following diagram (16):—


Sucrose per acre
Sucrose per stool
Number of stools per acre
Juice per stool
Per cent. sucrose in juice (6)
Weight of single stool
Per cent. juice in cane (5)
Weight of an average cane
Number of canes per stool (4)
Length of cane
Thickness of cane (3)
Density of cane (varies as per cent. juice)
Number of internodes per cane (1)
Average length of internode (2)

(*Note*: The features that are numbered in parenthesis are *genetic* but they are affected also by environmental circumstances).

Major characters deciding quantity of sucrose per acre apparently are:—

(*a*) volume of an average individual cane; (*b*) the number of canes per stool; (*c*) content of juice in cane, and (*d*) content of sucrose in juice.

It is helpful to regard the sugar-cane as a hollow porous reservoir into which sucrose, manufactured in the green top, is continuously being poured in solution and there accumulated and stored.

The porosity of the cane-stalk (which is decided mainly by the inherent morphology and minute anatomy of the cane variety), and its proportionate cellular volume, together determine the capacity of the cane for storing juice. The development of the cellulose scaffold which supports and encloses this vesicular system depends on the metabolic

activity of the green leaves comprising the cane-top (11c), and this in turn depends, not only on sunshine and air temperature, but also on the inherent efficiency of the leaves regarded as sugar manufactories, and on the rate and magnitude of the supplies of water, carbon-dioxide and nutrients which they absorb as raw materials from the environment. Recent research has proved that the dominating factor determining length of cane-stalk is undoubtedly temperature (11c).

As the vesicular system of the sugar-cane fills up with juice, a large proportion of the nutrients remains in the leaf-bunch. Thus it has been estimated that nearly two-thirds of the total nitrogen, about half of the potash and lime, and one-third of the phosphate, are contained in the tops when the canes are reaped (10b). Hence the cane grower should endeavour to incorporate all the cane-tops and the trash into the soil as manure. The rest of the nitrogen, lime, magnesia and phosphate is contained in the filter-press mud and the furnance ash, but much of the potash remains in the molasses, though some is lost in the flue dust. These factory residues should also be spread over the land wherever feasible. If successfully accomplished, a circulation of nutrients is thus initiated, but natural and unavoidable losses need to be made good by manurial additions.

The *number of stalks* or tillers per stool is partly decided by inherent or genetic factors and partly by environmental conditions; it is an important feature controlling sucrose production, and it has received considerable study by the plant breeder. Among the soil components that may be involved, phosphate and silicate have been shown to be important in deciding the degree of tillering of grasses, at least when grown in water culture(5).

The *sucrose content* of juice varies greatly in different varieties of sugar-cane grown under the same conditions, but it is markedly affected in any given variety by environmental factors, not only those relating to the soil and to systems of manuring (11b), but particularly climatic factors, as has already been noted. Among these, heat, expressed by "day degrees", has been shown to have especial significance (17). The ripening process, which is manifest by enhanced sucrose synthesis and storage, is believed to require periods of relatively low temperature for full realisation. Thus the ideal climate for cane-sugar production is one offering a long growing season followed by a short season sufficently cold to check vegetative growth and to encourage ripening (18).

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IMMUNIZATION AGAINST MALARIA

H. R. Jacobs (*Amer. J. Trop. Med.*, 23, 597; 1943), working on immunization against malaria, has shown that, in ducklings, the subcutaneous injection of saline-insoluble residues of *Plasmodium lophurae*, mixed with a staphylococcus toxoid, gives practically 100 per cent. immunity to malaria. The substance used is "an extract of protamide plasmodial precipitate insoluble in saline solution". It appears that such plasmodial substances insoluble in saline contain antigenic material which is effective, and that by addition of bacterial toxin its efficacy could be increased sufficiently to give promise of a wider application. F. F. Schwentker and F. C. Comploier (*J. Exp. Med.*, 70, 223; 1939) have shown that a toxoid combined with a non antigenic material served to make it antigenic. Jacobs does not claim that immunity is produced, but that effective protection against malaria is obtained; and he feels that the way is opened for the preparation of a good vaccine which will provoke an immunity so powerful that over-whelming doses of the parasites will be neutralized quickly.—(*Nature*, Vol. 154, No. 3912—1944).

THE ECONOMIC CONSEQUENCES OF AGRICULTURAL RESEARCH*

BY

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About a decade ago, an argument frequently advanced to justify a particular line of agricultural research ran somewhat as follows. The value of the Australian production of a particular crop is normally, say, *x* hundred thousand pounds per annum. A particular disease may be estimated to cause, on the average, a loss of *y* per cent. of the crop. Therefore—the conclusion was rarely stated baldly but was implicit in the argument—research which succeeded in eliminating the particular disease would be worth annually *xy* thousand pounds to the country.

A logical consequence of this argument was that, assuming the scientific problems involved to be of comparable complexity, research was regarded as roughly justified in proportion to the existing monetary value of the production in the particular branch of agriculture concerned. In fact, agricultural research tended to concentrate, though not exclusively, on the great export products.

During and after the depression, when the prices of Australia's agricultural exports fell heavily, and schemes were put in hand to limit production, the above argument began to sound less convincing and was less frequently heard. A tendency developed for agricultural research workers to devote their attention more to relatively minor products, particularly those in which the country was not self-supporting and in which the fall of prices had been less severe. Concurrently, research was encouraged in secondary rather than primary industries. In discussing the effect of the depression on scientific research, Sir David Rivett (*J. Counc. Sci. Ind. Res.*, *7*: 129, 1934) wrote as follows: "Nevertheless, one cannot ignore the bearing of present conditions upon the *raison d'être* of the C.S.I.R. and similar organizations. Suppose they suddenly wiped out all the possible causes, entomological, fungoid, and climatic, of loss in our apple orchards so that every tree produced a bumper crop. Is it not at least probable that the total price obtained for that crop, were it in gross excess of market demands, might actually be less than the total that would be given for a crop much smaller in quantity and just equal to or, better still, just a trifle below market demand?" Sir David went on to draw the logical, though rather melancholy conclusion, that more research should be devoted to the problems of gold production, gold being the one commodity of which the price was increased during the depression.

With the lifting of the depression, discussion of the subject again fell somewhat into abeyance. In agricultural research a rather haphazard balance has been maintained between the claims of different branches of agriculture. Within the C.S.I.R., for instance, work on wheat, a crop which suffered very severely in the pre-war decade, has been largely suspended, while, on the other hand, increased attention has been devoted to the problems of the grazing industry. The reasons for research to be concentrated on particular branches of agriculture are not always apparent, and it may be that, not infrequently, the willingness of the producers concerned to contribute towards the cost of a particular investigation is a major factor.

It is the purpose of this paper to urge the necessity for an investigation, to be conducted jointly by economists and agricultural scientists, into the economic implications of agricultural research, so that particular research projects may be assessed, not only on their scientific possibilities, but also on their desirability in the broader economic background of national life. The notes which follow, admittedly tentative, attempt no more than to raise some of the problems which await investigation.

Economic Objectives and Applied Research

In a recent discussion (Anon, *Economist*, Sept. 4th 1943) of economic objectives the following sentences appear: "In the twentieth century, economic policy has three objects. They have been defined by Professor Pigou as being to increase the national income (the old policy of increasing the sum total of wealth), to improve the regularity of the national income and to improve its distribution among the individual members of the community."

It is clear that, within its limited field, agricultural research can make useful contributions towards each of these objectives. Probably the greater part of research in the past has been directed consciously or unconsciously towards the first objective. The aim has been to increase production per unit area, at the same time reducing the unit costs of production The breeding of higher yielding varieties of crop plants is a good example of work of this nature. Some lines of research, while perhaps incidentally serving to increase the sum total of agricultural incomes, have as their more immediate objective the desire to reduce the seasonal fluctuations in income. Such are research projects designed to mitigate the adverse effects of drought, or to control diseases which fluctuate greatly from season to season. Finally, some work—that devoted more particularly to the problems of marginal areas and the marginal producer—may help to improve the distribution of the aggregate agricultural income among the individual members of the community.

*Reprinted from *The Journal of the Australian Institute of Agricultural Science*, Vol. 9, No. 4, pp. 163-166, December, 1943.

While, as instanced above, successful research may promote more than one of the three economic objectives, it is perhaps less generally recognized that the three are not always mutually compatible, and it may be that the immediate effect, at least, of a particular line of research may be to aggravate inequalities of income. This will be made clearer if we attempt to consider the probable effect of successful research designed to reduce the unit cost of production of a major agricultural or pastoral product. In the first place, it is rarely, if ever, true that the results of agricultural research are equally applicable to all producers of the crop concerned. Almost invariably the solution of a particular problem will be applicable principally to a particular region or regions as for instance, those in which the disease studied is especially prevalent. In so far as the application of the results of the research leads to increased production in such areas, it will tend, in greater or less degree, to depress the price of the product. This in turn will adversely affect the returns obtained by producers in other areas, and the marginal producers in such areas may well be faced with losses.

Further, the results will by no means be equally beneficial to all producers even in the areas to which it is particularly applicable. Application of the results of research to agricultural production usually, if not invariably, involves the producer in extra expense. This is true whether the measures recommended involve the reduction of disease by spraying, or increasing wool or meat production by the subdivision or top-dressing of pastures. Such extra costs may be readily met by the more prosperous producers, but the marginal producers may be in no position to pay out more money. They will thus be faced with the same difficulties as marginal producers in other areas, and the net result of the research may well be to favour the more prosperous farmers at the expense of the less prosperous ones.

Various possible objections to the above contentions may be examined briefly. They are, of course, concerned only with the *immediate* effect of the application of scientific methods, and it may be maintained that the long-period effects will be beneficial to the country as a whole and to all the producers concerned, as a result of the broader market obtained by the lower prices. In this connection, it will be well to recall Lord Keynes' famous phrase: "In the long run, we are all dead." It will be cold comfort to the marginal producer, faced with heavy losses and possibly forced off the land, to reflect that, if only he could have survived for a few more years, he might have been able to sell his products in China—if the Chinese could afford to buy them! In fact, of course, the marginal producer will not be content to die quietly; he will press for protection in the form of bounties, fixed prices, or in other ways. To discuss the consequences of this would involve consideration of international repercussions and would be out of place here.

It may be urged, too, that scientific advances are rarely sudden, and that their applications, partly owing to the inadequacies of the extension service, are too gradual to have any considerable effect on prices. These objections may be admitted, but it is not clear that they affect the above arguments except in degree, and it would perhaps be unwise for agricultural scientists to stress too strongly the relative insignificance of the results of their researches!

More fundamental is the objection that the adverse effects on marginal producers of the application of agricultural research will only take effect if the increased production envisaged does, in fact, influence prices. This involves considerations which come near to the heart of our problem, and on which a fuller investigation is urgently required.

Production, Prices and Research

In the absence of a system of price control, it may be said that the effect on prices of increased Australian production of any primary product will vary according to the ratio of Australian production to the total marketed crop, and according to the elasticity of demand for the product concerned.

During the period prior to 1939, wool was the outstanding instance of a product in which Australia accounted for the bulk of the world's marketed production. A relatively small percentage increase in Australian wool production, whether due to research or other causes, would be likely to have a quite appreciable effect on world prices. In fact, a comparison of Australian wool production and prices before the war suggests that, on the whole, years of high production did coincide with low prices, and even that the total sum obtained by producers was less for a large than for a small clip. This is the situation envisaged by Sir David Rivett in the paragraph cited above, and is one which has been found to apply to the American cotton crop.

The Australian output of some other primary products—dried fruits, butter etc.—was restricted, legally or otherwise, before the war, because it was believed that the available market was inelastic, and that the attempt to market increased quantities would lead to a disproportionate fall in price. It is unnecessary to stress, in this connection, that the available market, particularly for perishable products, may represent only a small part of the total world market.

It may be seriously questioned whether research, designed to increase production by reducing unit costs, is justified in the case of commodities such as those mentioned above. Such research, if successful, would be likely to lead to the adverse effects on equality of incomes discussed in the previous section, with a consequent upsetting of the balance of the industry. On the other hand, there seems to be ample justification for research designed to overcome seasonal fluctuations, or to improve the lot of the marginal producer.

In contrast to these major export products may be mentioned those in which Australia is less than self-sufficient, or in which Australian production is only maintained by protection in the form of tariffs and bounties. Here any research which had the effect of reducing unit costs would appear

to be wholly beneficial; outstandingly so if it enabled Australia to produce competitively commodities for which her costs of production were previously above world levels. This applies, too, to products for which a rapidly expanding market is available, or for those in which the market is highly elastic.

Conclusion

The post-war world will, almost certainly, be one of regulated economy, and it is vital that the different branches of that economy should be correlated and work towards the same ends. If we accept Professor Pigou's definitions of the aims of economic policy, these aims must be kept constantly in mind in all decisions involving long-term action. It is true, no doubt, that if the results of a particular line of agricultural research should conflict with one or other of these objectives, compensatory action could be taken in the economic field, but, at best, the necessity for such compensation would greatly reduce the value of the work.

The post-war world is, admittedly still obscure, but it is not entirely dark. Forecasts have been made of probable changes in Australian primary production, and it is not too soon to enquire into the bearing of such changes on agricultural research. Shall we, for instance, concentrate on the problems of those branches of agriculture which appear likely to expand, or rather on the mitigation of the inevitable disruption in those which may contract? On the problems of marginal producers and marginal areas, or on those of more favoured districts? What measures are necessary to ensure that the benefits of research accrue to as many producers as possible?

On all these problems, a joint enquiry of economists and agricultural scientists would be of value, and would clarify the issues when detailed projects come up for consideration. In so doing, it would help to ensure that any long-term research project undertaken could be carried through to its conclusion, and not, as has happened in the past, be suspended because it appeared to have outlived its economic usefulness.

This discussion has but skimmed the surface of the problems, and no account at all has been taken of many secondary consequences of successful agricultural research. Yet it will have served its purpose if it has drawn attention to the fact that the "conflict between progress and security", to which so much attention is being given elsewhere is not without relevance in a consideration of desirable directions of agricultural research. The decision on whether research should be undertaken on one line rather than another, or on the production of one commodity rather than that of another, is not one to be made by the agricultural scientist alone. He is best able to judge the possibilities of success of any particular investigation, but he must seek the co-operation of the economist in deciding whether such technical success will in fact serve the best interests of the agricultural community as a whole.

COMPETITIVE RUBBER PLANTS *

Far more plants contain rubber than is generally realised, but few contain enough to make extraction worth while. The Russian dandelion, kok-saghyz, is similar in general appearance to English dandelions, but contains a much higher proportion of rubber, usually about 10 per cent. Experiments on the cultivation of kok-saghyz are being made in Great Britain.

The rubber-bearing plants of Great Britain are few and insignificant compared with those in other parts of the Empire. According to a report of the Imperial Agricultural Research Institute of India, there are in that country 268 species of plants which are stated to contain rubber. Although it would appear that the Empire is rich in rubber-yielding plants, most of them yield a complex mixture of vegetable substances of which rubber forms only a small percentage. No product containing less than 20 per cent. is likely to be of value as a source of rubber, and even this proportion raises difficulties. Probably the best known of these plants is the bush *Euphorbia tricualli* and other species of *Euphorbia* in South Africa. One tapper can collect about two gallons of *Euphorbia* latex a day, which is equivalent to about 6 lb. of solids containing, at the most, 1 lb. of rubber.

It is probably easier and more economical in man-power and materials to find use for the unpurified product in directions where the strength and elasticity of rubber are only required to a mild extent. This is the policy which has been pursued in Great Britain in connection with the utilization of Niger paste, which is the coagulated latex of *Carpodinus hirsuta*, a vine widely distributed in West Africa. The paste contains little over 10 per cent. rubber hydro-carbon, but intensive investigations by a number of organisations have indicated directions in which it can be used without purification. The rubber-bearing plants of importance in the present emergency yield products containing at least 75 per cent. hydro-carbon and some of them between 85 and 90 per cent. which is almost as pure as rubber produced on the Eastern plantations. Reference should be made, however, to a tree, *Ficus vogelii*, widely distributed in the forests of West Africa, which yields a product containing 50 per cent. rubber hydro-carbon. The source which dominates all others is, of course, *Hevea brasiliensis*, which is not ready for tapping until five years after planting. Each mature tree yields about 5 lb. of rubber per annum. In the case of a small plant, such as kok-saghyz, it is possible to envisage a cheap annual crop based on mechanical cultivators, harvesters and mass-production factories.

A considerable amount of attention is now being devoted to a woody climber, known as *Cryptostegia grandiflora*, which is a native of Madagascar,

(Abstract from a paper by G. Martin in *Nature*, vol. 153, No. 3877, 1944, p. 212).

but grows like a weed in Northern Australia, in various parts of India, in Florida and the West Indies. The rubber is not quite as good as that from Hevea, but contains about 75 per cent. hydrocarbon and can be used satisfactorily for practically all purposes. Other sources of rubber were intensively developed thirty years ago and have only faded into the background because of the economic predominance of Hevea.

The most important of the trees is *Funtumia elastica*, which is widely distributed in the forests of west and east tropical Africa. Another tree which attracted much attention in the early days is *Manihot glasiovii*, more popularly known as ceara. It is a smaller tree than Hevea and can be planted more densely. The most important indigenous sources of rubber in Africa are the numerous woody large vines, widely distributed in the tropical forests. The principal genera are *Landolphia*, *Clitandra* and *Carpodinus*, containing numerous species. In normal circumstances vine rubber cannot hope to compete with plantation rubber produced in the Far East, chiefly because the harvesting of the rubber involves the same type of operations with much smaller yields and more difficult conditions. This comment does not apply, however, to some species of Landolphia, etc., particularly *Landolphia thollonii*, which, growing in poor soil in open country does not develop into a climbing plant, but throws out long underground stems ramifying in all directions, with small tufts of foliage above ground at irregular intervals. The stems have been known to reach sixty yards in length and as they are only a few inches below the surface they are not difficult to gather and cut off near the tap root. A survey of competitive rubber plants would not be complete without a reference to Castilloa and *Ficus elastica*. Both have been cultivated on a small scale in different parts of the Empire, but on account of small yields, and for other reasons, cannot hope to compete with Hevea after the War.

Trees which have to go through the same cycle of operations as Hevea in order to obtain rubber are hopelessly outclassed by the latter with regard to yield, quality and ease of treatment. Small plants may be more successful, however, because their cultivation and treatment can be mechanized, and operations can be based on an annual instead of a daily cycle.

CHEMICAL NOTES

(Compiled by the College Department of Chemistry and Soil Science)

Effect of Temperature and Humidity on Viability of Stored Seeds in Hawaii

The effect on seed viability of various relative humidities and of low temperatures as well as a combination of the two was studied at Honolulu over a period of 6 years. The results obtained are regarded as applicable to Hawaii where similar climatic conditions prevail and where the storage of seed has now become a matter of major importance. The following seeds were tested :—garden bean, maize, soybean, lucerne, rice, lettuce and *Pennisetum ciliare*. It was found that both low relative humidities of 15-45 per cent. at ordinary room temperatures of 71-80°F. and low temperatures of 45-50°F. at ordinary relative humidities of 64-73 per cent. constituted excellent conditions for longevity of stored seed. A combination of controlled humidity and controlled temperature increased viability further. Small quantities of seed are stored safely in the dry part of a family refrigerator. (*Bull. Hawaii Agric. Exp. Stat.* 90, 1943, pp. 23).

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A Note on Ascorbic Acid : Nitrogen Relationships in Grapefruit

Extensive tests conducted at the Agricultural Experiment Station, University of Arizona, showed a negative correlation to exist in Marsh grapefruit between nitrogen and ascorbic acid content. Fruits from trees so managed as to give a low nitrogen content at harvest were consistently found to contain 20-25 per cent. more ascorbic acid than those from trees with a higher nitrogen level. Grapefruit juice gave a negative correlation coefficient between nitrogen and ascorbic acid content of 0.91. Incidentally, the values reported for ascorbic acid content in grapefruit juice from low level nitrogen trees are exceptionally high : .53 – .59 mg./ml. for fruits picked 30th September, 1942 and an average of .44 – .48 mg./ml. for fruits harvested during the period 30th September, 1942 to 2nd February, 1943.—(*Horticultural Abstracts*, Vol. XIV, No. 3, 1944.)

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Influence of Organic Manures on Bud Growth of Cane Plants

Following suggestions that organic manures may have some influence, over and above their fertilizer value, on the bud growth of cane plants, a trial was laid out in Queensland on which one plot received 25 tons of farmyard manure per acre, another the equivalent in nitrogen, potassium, and phosphorus, and a third was kept as control. Two varieties of sugar-cane were used, and the soil was comparatively new. Eight months after the application of the manures, and when the young plant cane had made good growth, setts were cut and planted out in three trials. There was no apparent effect from the organic manure treatment, but it remains to be seen whether there would have been some results on plants grown on an old worn-out soil—(*Soils and Fertilizers*, VII, No. 3, 1944. See *43rd Annual Report of the Bureau of Sugar Experiment Stations*, Queensland).